JPL
Campus Network
Advanced Services

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Agenda

- Building Blocks
- State of the Network
- Advanced Services
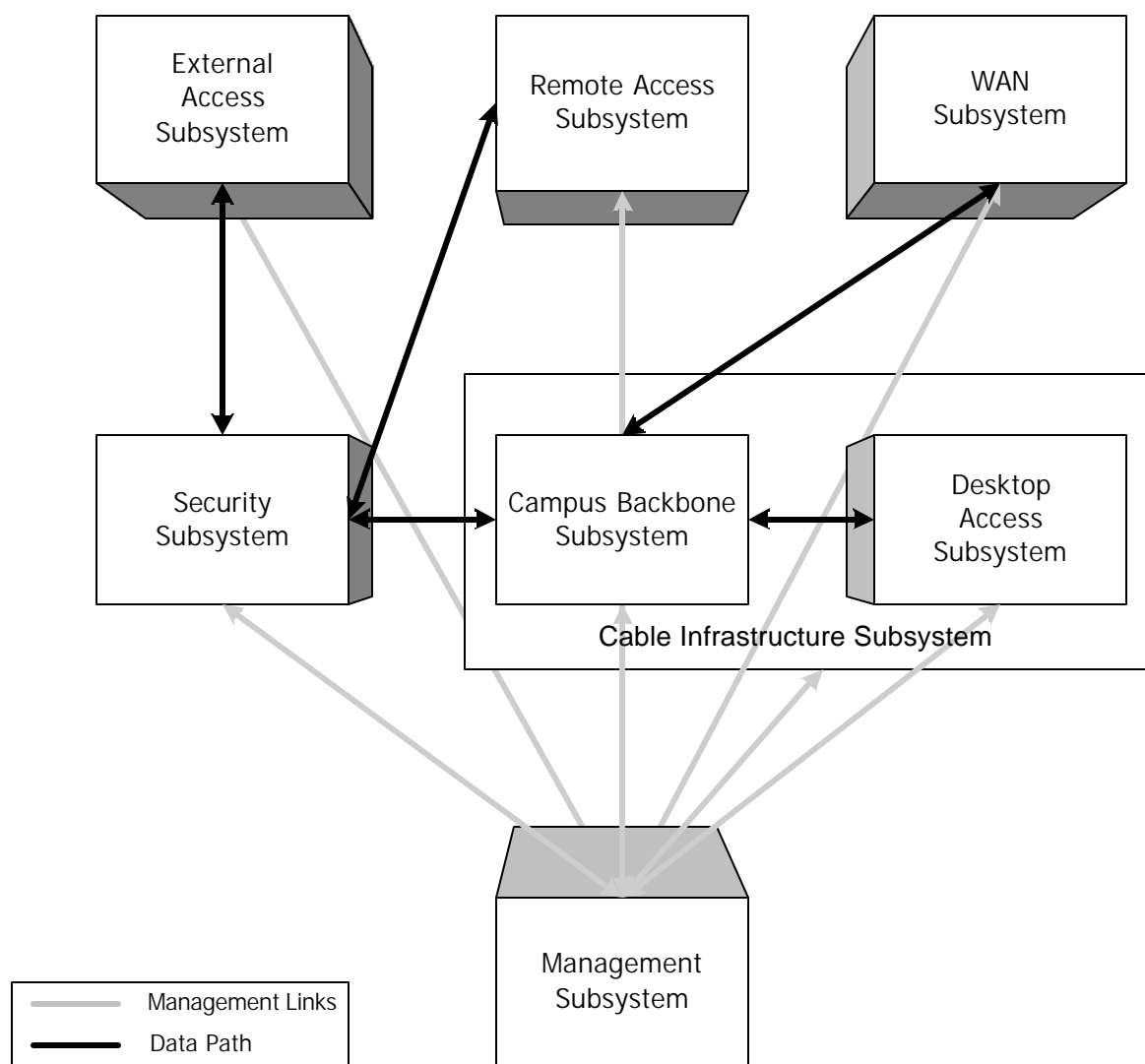- Future
- Case Studies
- Conclusions

Building Blocks

- **Support**
  - Management
  - Direction
  - Funding
- **Centralization**
  - Economies of scale
  - Operations & Configuration Management
- **Infrastructure**
  - Cabling
  - Equipment
  - Star Topology
  - Monitoring

Network Subsystems

External Access Subsystem

Remote Access Subsystem

WAN Subsystem

Security Subsystem

Campus Backbone Subsystem

Desktop Access Subsystem

Cable Infrastructure Subsystem

Management Subsystem

Management Links

Data Path

JPL Campus Advanced Services

Current
State of the Network

- **Structured Cabling**
  - 3 Category 5 to each work location
  - 6MM to select work locations
  - 6SM/18MM riser
  - 12SM/12MM between buildings
- **Fully Switched**
  - 10/100Mb/s to each desktop [10Base-T/100Base-TX]
    - Limited only by Network Interface Card (NIC) on system
  - 1000Mb/s for approved systems [1000Base-SX]
- **Multi-Gigabit Core**
  - 18 Cisco 8540 L2/L3 switches interconnected via GigE
- **Deterministic**
  - 2 Hops
  - Consistent Edge and Backbone Hardware

Current
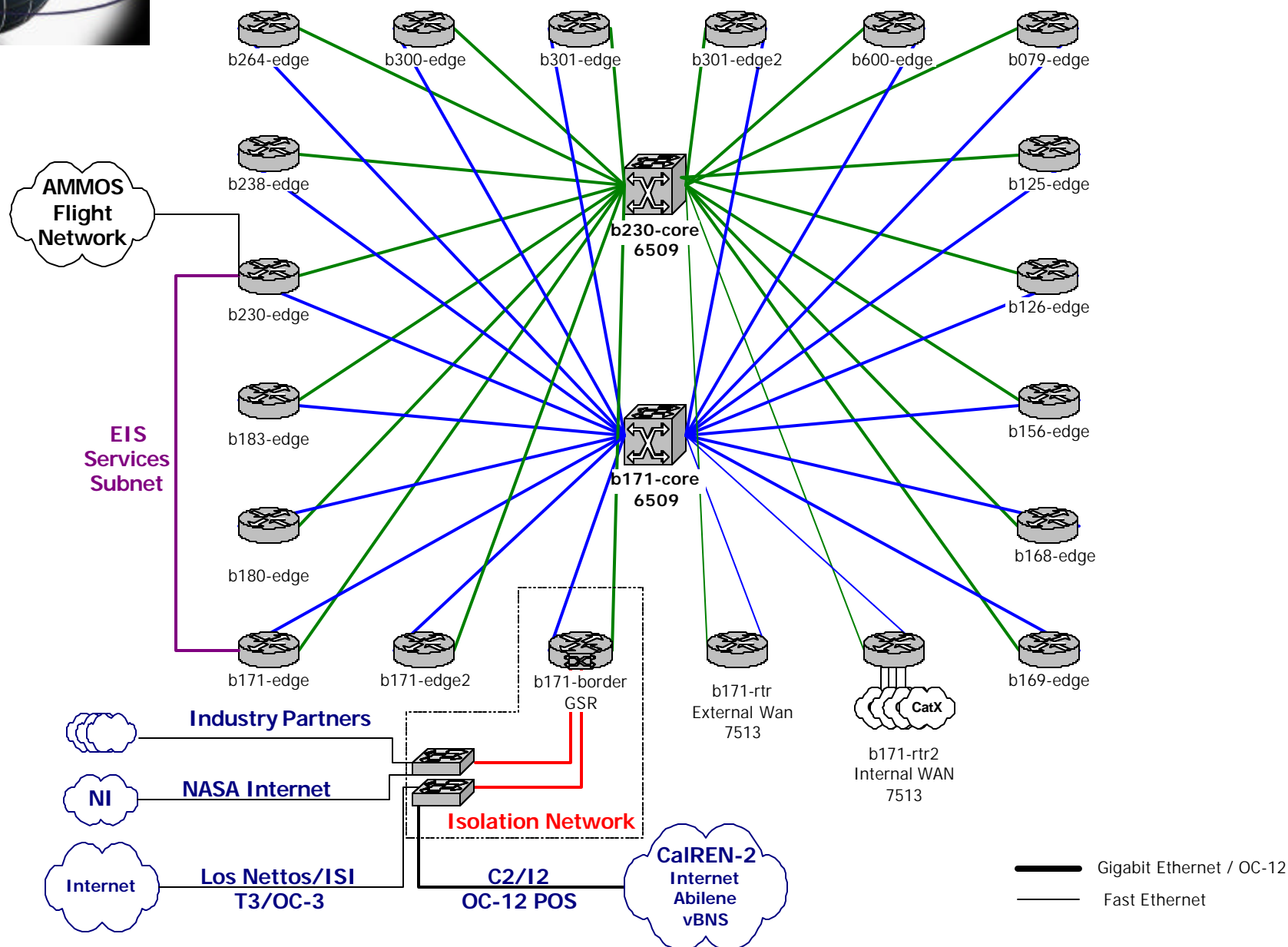# State of the Network (cont..)

- **Management & Monitoring**
  - 700+ Network Devices monitored via Aprisma Spectrum
  - 20,000+ interfaces monitored via Concord Nethealth
  - 1000Base-SX and 100Base-TX/FX RMON probes
- **External Connectivity**
  - OC-12s (622Mb/s) to CaIREN-2
  - T3 (45Mb/s) to commercial ISP
  - OC-3 NASA Networks (155Mb/s)
    - ~50Mb/s to Production Networks
    - ~100Mb/s to Research Network (NREN)

JPLNet Gigabit Backbone OAK GROVE / IPC

JPLNet

JPL

b264-edge b300-edge b301-edge b301-edge2 b600-edge b079-edge

b238-edge

AMMOS Flight Network

b125-edge

b230-edge

b126-edge

EIS Services Subnet

b183-edge

b230-core 6509

b156-edge

b180-edge

b171-core 6509

b168-edge

b171-edge b171-edge2 b171-border GSR b171-rtr External Wan 7513 b171-rtr2 Internal WAN 7513 b169-edge

CatX

Industry Partners

NI **NASA Internet**

Isolation Network

Internet **Los Nettos/ISI T3/OC-3**

C2/I2 OC-12 POS

CalREN-2 Internet Abilene vBNS

—— Gigabit Ethernet / OC-12

—— Fast Ethernet

Advanced Services

- Gigabit to the Desktop
- Tuning
- Measurement
- Multicast/Video
- Security
- Jumbo Frames/Larger MTU
- IPv6
- Quality of Service
- Other?

Gigabit to the Desktop

- **If a system meets:**
    - Minimum Hardware Criteria
    - Usage Justification
    - Current Port Utilization Criteria
- **A system gets:**
    - Fiber Drop (6 strand MM)
    - 1000-Base-SX Port
        - 6509
        - 4003
        - 2948
    - Tuning Guidelines

Tuning

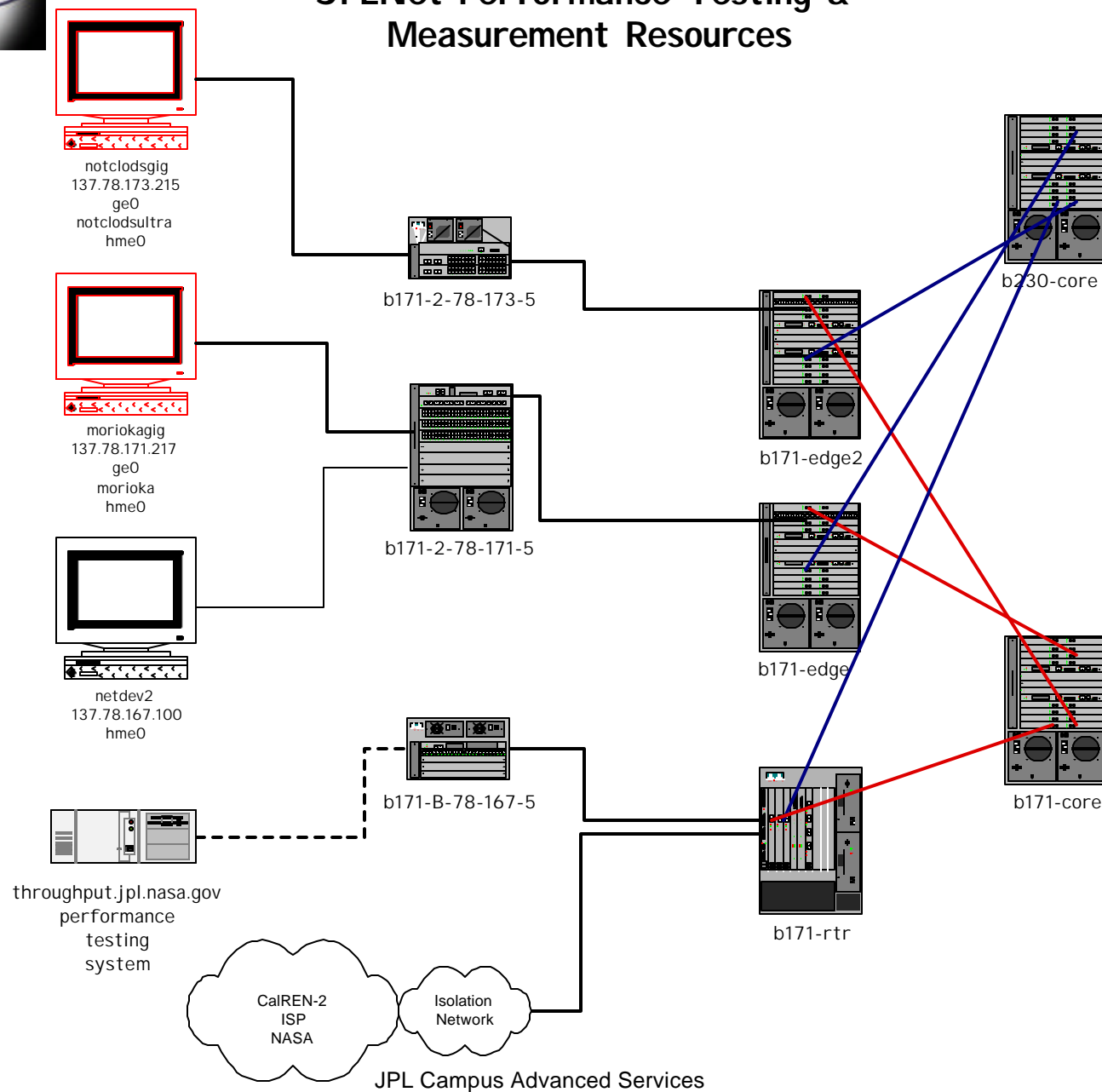- **Duplexing**
  - White Paper
- **TCP**
  - White Paper & References

JPL Campus Advanced Services

Measurement

- **Concord NetHealth**

- **Netsys Gigabit Ethernet RMON Probes**

- **Real Time performance Testing Planned**

  – Performance Testing System

    - FreeBSD, Dual Processor, RAID

    - Anonymous? FTP

    - ttcp (ttcp.jpl.nasa.gov), nttcp (nttcp.jpl.nasa.gov)

    - netperf (netperf.jpl.nasa.gov), iperf (iperf.jpl.nasa.gov)

    - endpoint (endpoint.jpl.nasa.gov) (NetIQ, formerly Ganymede)

    - Web page describing connectivity, TCP parameters, Contact Information

    - Internal reference, External reference

    - Looking glass traceroute functionality

    - Procedures TBD

JPLNet Performance Testing & Measurement Resources

notclodsgig
137.78.173.215
ge0
notclodsultra
hme0

moriokagig
137.78.171.217
ge0
morioka
hme0

netdev2
137.78.167.100
hme0

throughput.jpl.nasa.gov
performance
testing
system

b171-2-78-173-5

b171-2-78-171-5

b171-B-78-167-5

CalREN-2
ISP
NASA

Isolation
Network

b230-core

b171-edge2

b171-edge

b171-core

b171-rtr

JPL Campus Advanced Services

Multicast/Video

- **Campus Community**
  - MPEG-1
  - MPEG-2
  - White Paper
- **External Community**
  - What format?
  - What data rates?
  - How to distribute?

Security

- **Firewall**

  - Support for OC-12/Gigabit Ethernet forwarding rates

  - Appliance

  - Research Networks
    - OC-48 to CalTech
      - tape silos
      - shared storage

Jumbo Frames

- **Localized for now**
  - Supercomputer Subnet(s)
- **Cross Country?**
  - JPL/GSFC Aqua Testing

Future

- **Advanced Services**
  - IPV6
  - Quality of Service
  - Other
    - Self Tuning
- **Advanced Measurement and Monitoring capabilities**
  - Loss (Better Way to Measure)
  - Latency
  - Jitter
  - TBD

Case Study
Digital Sky Demo

- **NREN Gigabit Workshop**

    – Demonstrate large data set retrieval from 4 distinct geographic locations and real time rendering **using production networks**
    - Goddard Space Flight Center
    - California Institute of Technology
    - Jet Propulsion Lab
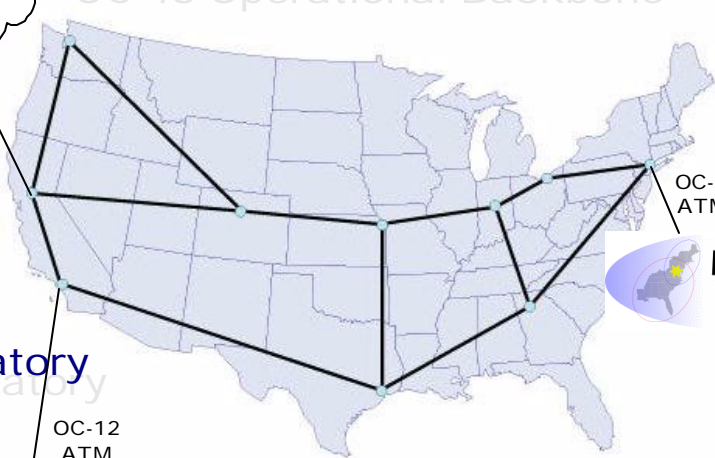   - AMES Research Center

JPL Digital SKY Presentation
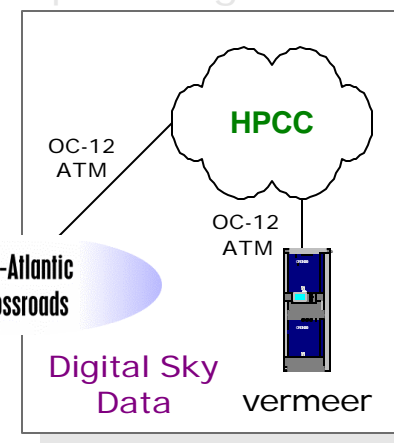## NREN Gigabit Networking Workshop
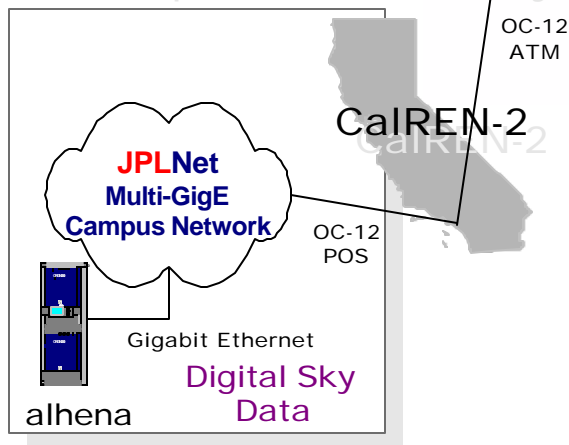### August 15-16,2000

Ames Research Center

OC-12 ATM

NREN

NGIX West

OC-12 ATM

Digital Sky Display

barney

Abilene
OC-48 Operational Backbone

OC-12 ATM

OC-3 ATM

Mid-Atlantic Crossroads

Goddard
Space Flight Center

OC-12 ATM

HPCC

OC-12 ATM

Digital Sky Data

vermeer

Jet Propulsion Laboratory

OC-12 ATM

CalREN-2

JPLNet
Multi-GigE Campus Network

OC-12 POS

Gigabit Ethernet

Digital Sky Data

alhena

Case Study
Digital Sky Demo

- **Tools**
  - ping, traceroute
  - iperf, netperf, ttcp, NetIQ (Ganymede)
  - network equipment interface statistics
- **Issues with troubleshooting**
  - Tools to measure throughput and packet loss
  - System Tuning
  - Test Points & Contacts
    - Finding
    - Setting up

JPL Digital SKY Presentation
NREN Gigabit Networking Workshop
Contributions
August 15-16,2000

Ames Research Center

Richard desJardins
Mark Foster
David A. Guevara
Hugh LaMaster
Matt Chew Spence
NREN

Abilene
OC-48 Operational Backbone

Matthew Davy
Brent Sweeny
Abilene NOC

Goddard
Space Flight Center

William E Fink
J. Patrick Gary
Paul Lang
Dr. Horace Mitchell
George Uhl
HPCC

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Mid-Atlantic Crossroads

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Jet Propulsion Laboratory

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Lucian Plesea
Chris Windoffer
JPLNet

CalREN-2

Brian Court
Erick Sizelove
CalREN-2 NOC

Special thanks to Ron Roberts of Stanford University and Jim Warner and Mark Boolootian of UC Santa Cruz, CalREN-2 members who assisted us in troubleshooting

All the people named here were directly involved in testing, troubleshooting, and optimizing the links that provide network connectivity for this demonstration.

It is certain that others were involved behind the scenes and just as certain that we cannot name them all here. This does not lessen their contribution nor our gratitude towards them.

C. de Luna - 2000-08-13
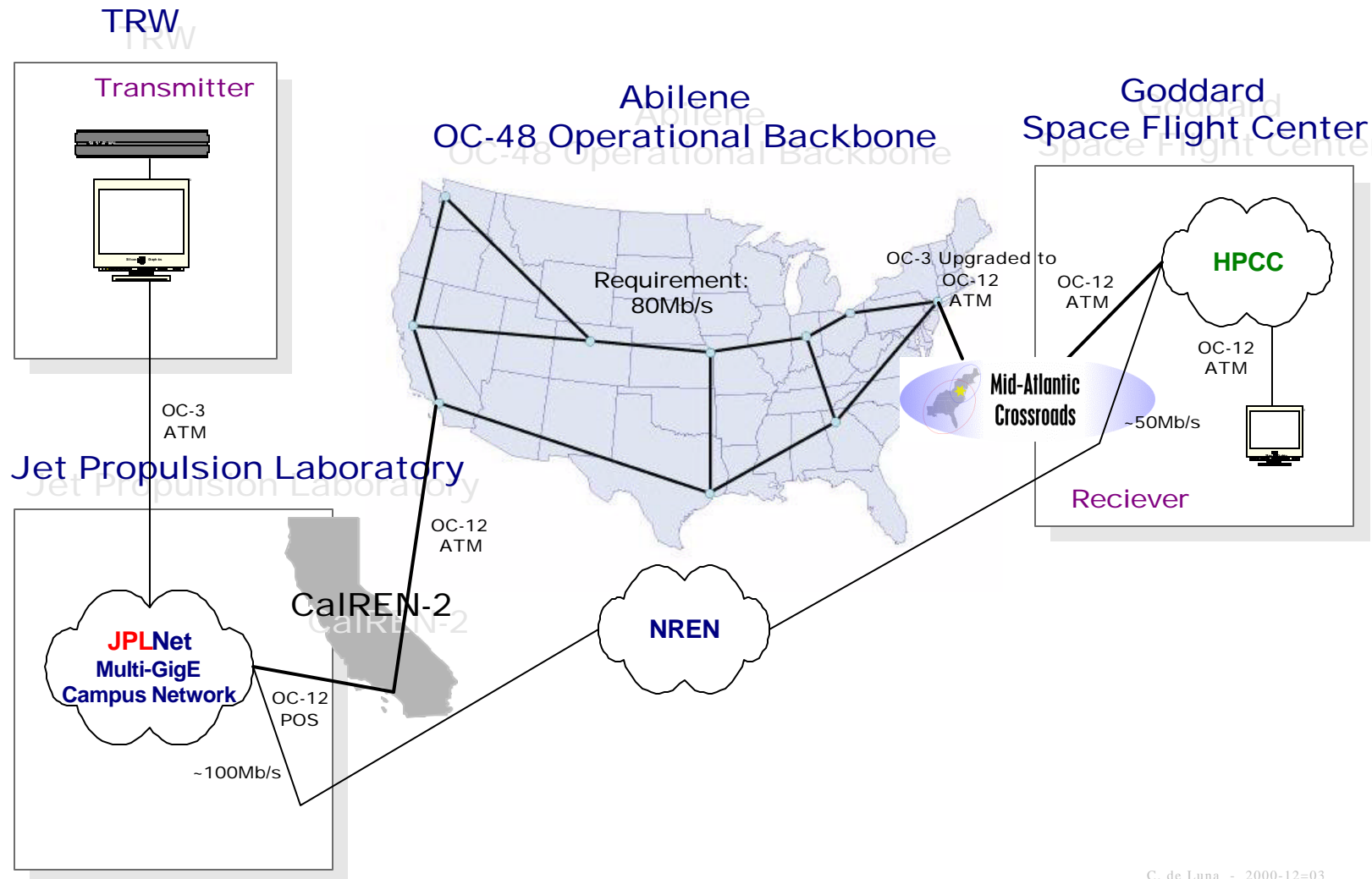JPL-DigitalSkyPresentation-Participants.vsd

Case Study
EOS Aqua Prototype

- **NASA's Earth Observing System (EOS) Aqua Spacecraft**

- **Prototype clock and data delivery over IP**

  - 80Mb/s

  - From TRW to GSFC

    - over Internet 2 infrastructure
    - over NREN

Goddard Space Flight Center
EOS Aqua Clock & Data Protoype

JPLNet

JPL

TRW

Transmitter

Abilene
OC-48 Operational Backbone

Goddard
Space Flight Center

OC-3 Upgraded to
OC-12
ATM

OC-12
ATM

HPCC

Requirement:
80Mb/s

OC-12
ATM

OC-3
ATM

Mid-Atlantic
Crossroads

~50Mb/s

Reciever

Jet Propulsion Laboratory

OC-12
ATM

CalREN-2

JPLNet
Multi-GigE
Campus Network

NREN

OC-12
POS

~100Mb/s

C. de Luna - 2000-12=03

Case Study
EOS Aqua Prototype

- **Tools**
  - ping, traceroute, pathchar
  - iperf, netperf, ttcp, nttcp
  - network equipment interface statistics

- **Issues with troubleshooting**
  - Tools to measure throughput and packet loss
  - System Tuning
  - Test Points
    - Contacts
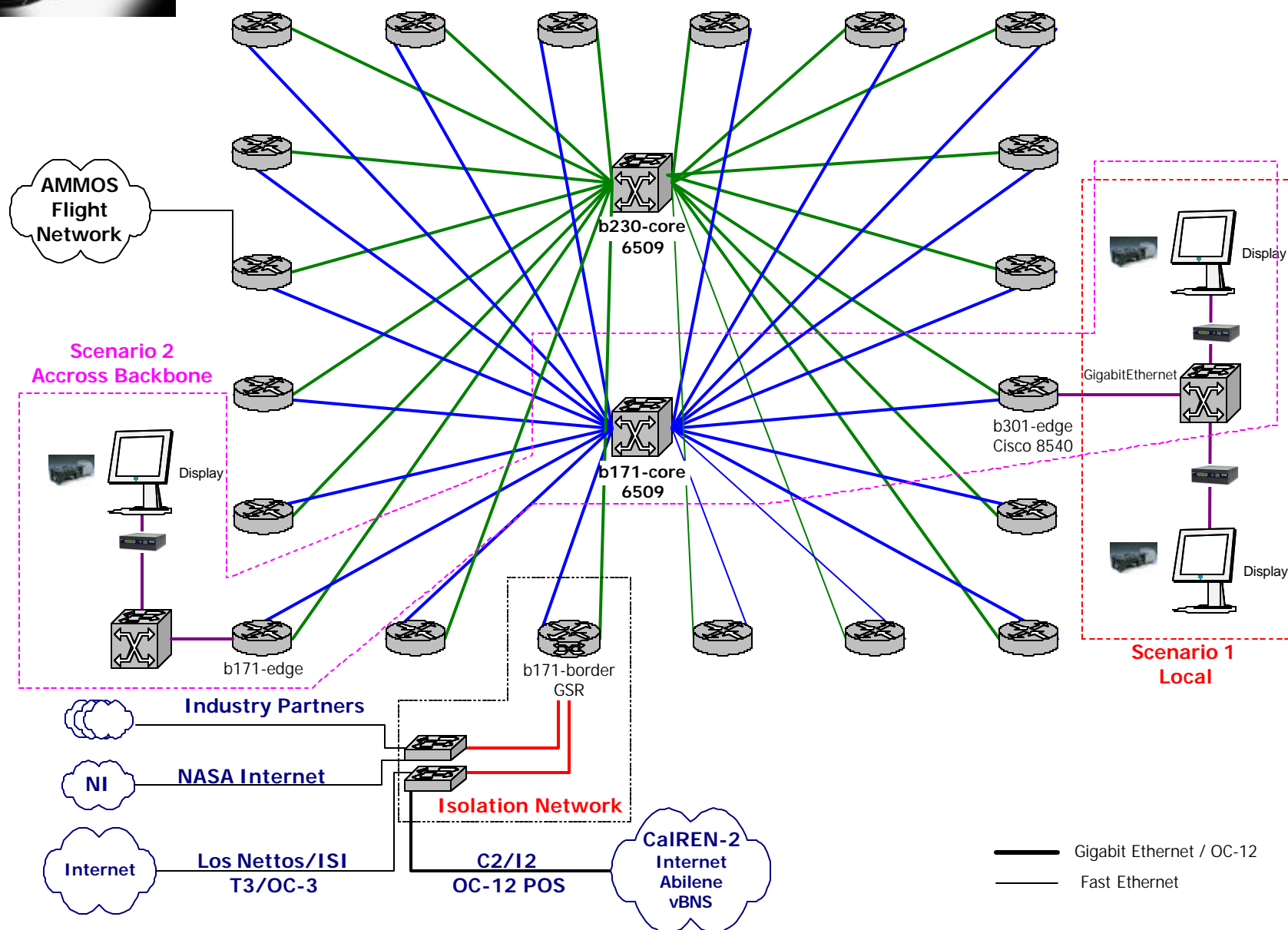   - Finding
    - Setting up

Case Study
HiDef Demonstration

- **HiDef Virtual Co-location**

  – Vendor brought in special systems to packetize HiDef video

  – Requested 4 Gigabit Ethernet ports

- **Testing Scenario 1**

  – Across a 6509

- **Testing Scenario 2**

  – Across the backbone

JPLNet Gigabit Backbone
HiDef Demo

JPLNet

JPL

AMMOS Flight Network

b230-core 6509

b171-core 6509

Scenario 2 Accross Backbone

Display

b171-edge

b171-border GSR

b301-edge Cisco 8540

GigabitEthernet

Display

Display

Scenario 1 Local

Industry Partners

NI

NASA Internet

Isolation Network

Internet

Los Nettos/ISI T3/OC-3

C2/I2 OC-12 POS

CalREN-2 Internet Abilene vBNS

Gigabit Ethernet / OC-12
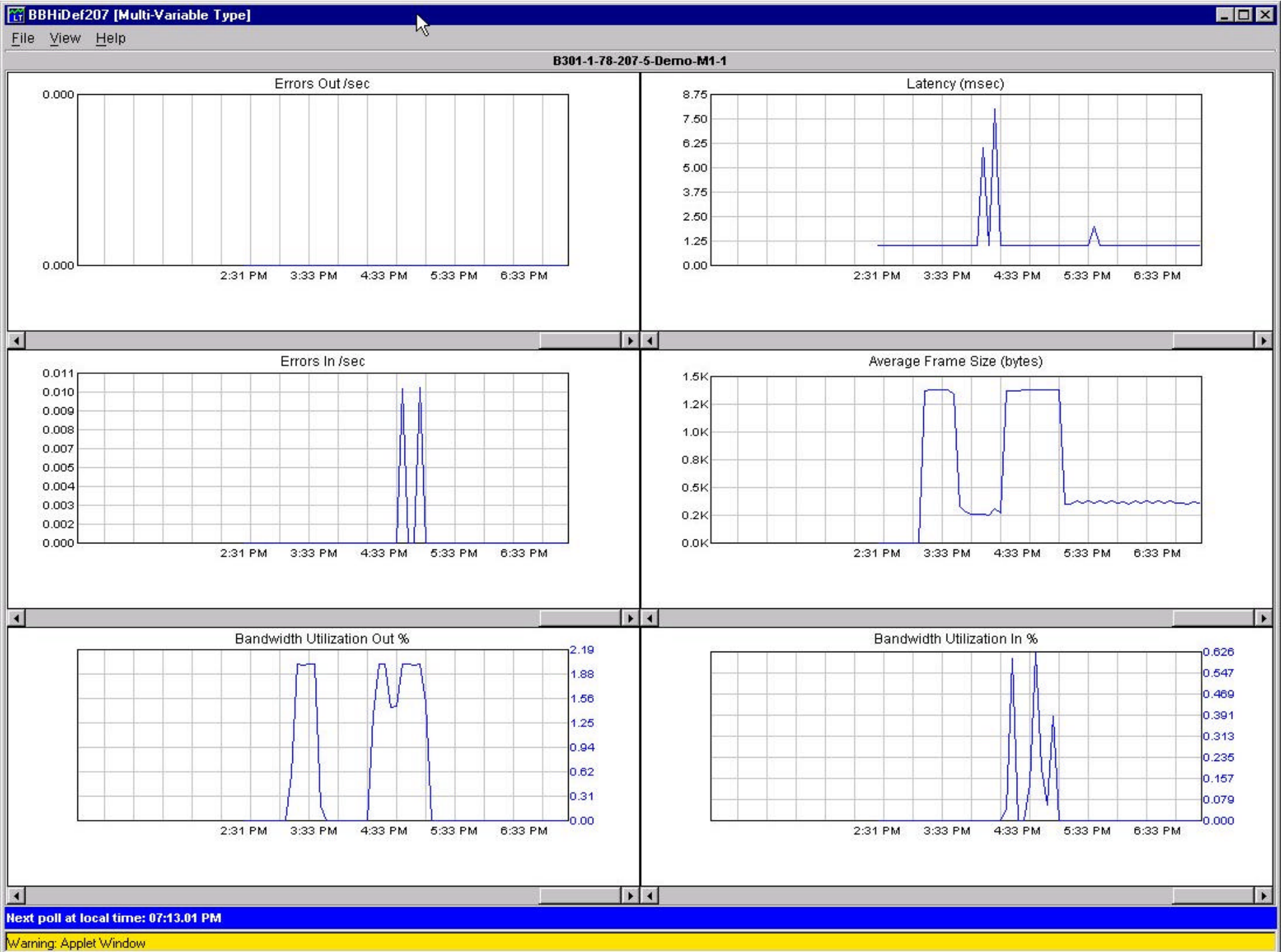
Fast Ethernet

Case Study
HiDef Demonstration

- **Tools**
  - Concord Nethealth and LiveTrend
  - Cisco Works
  - Network equipment interface statistics

- **Issues**
  - Tools to measure latency, jitter, packet loss, and throughput of network and network components
  - Tools to measure end system relevant parameters
    - CPU
    - Bus
    - NIC
    - Memory
 - System Tuning
  - Test Points
  - Vendor Education

File View Help

B301-1-78-207-5-Demo-M1-1

Errors Out /sec

0.000

0.000
2:31 PM   3:33 PM   4:33 PM   5:33 PM   6:33 PM

Latency (msec)

8.75
7.50
6.25
5.00
3.75
2.50
1.25
0.00
2:31 PM   3:33 PM   4:33 PM   5:33 PM   6:33 PM

Errors In /sec

0.011
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
2:31 PM   3:33 PM   4:33 PM   5:33 PM   6:33 PM

Average Frame Size (bytes)

1.5K
1.2K
1.0K
0.8K
0.5K
0.2K
0.0K
2:31 PM   3:33 PM   4:33 PM   5:33 PM   6:33 PM

Bandwidth Utilization Out %

2.19
1.88
1.56
1.25
0.94
0.62
0.31
0.00
2:31 PM   3:33 PM   4:33 PM   5:33 PM   6:33 PM

Bandwidth Utilization In %

0.626
0.547
0.469
0.391
0.313
0.235
0.157
0.079
0.000
2:31 PM   3:33 PM   4:33 PM   5:33 PM   6:33 PM

Next poll at local time: 07:13.01 PM

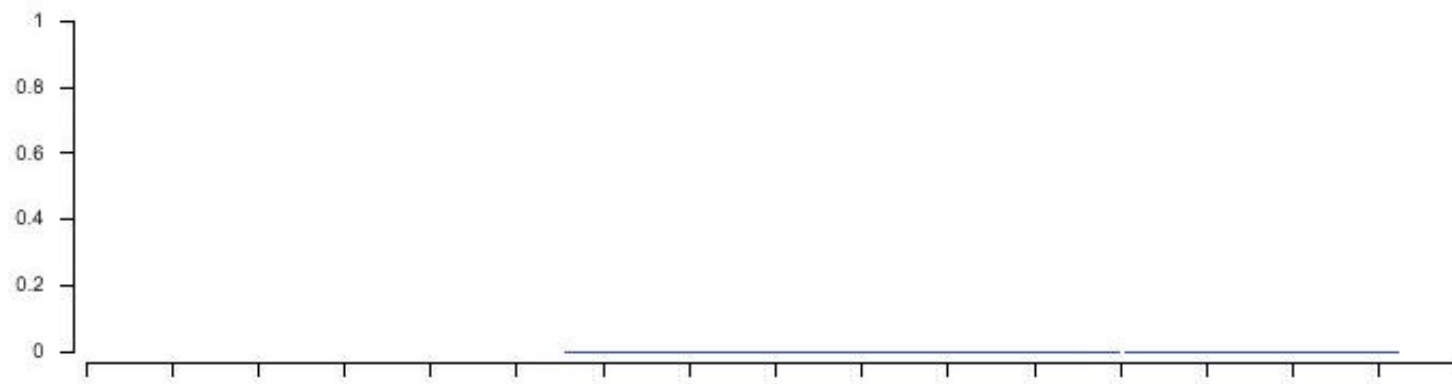Warning: Applet Window

At-a-Glance Report

Switch Backplane Element B301-1-78-207-5-Demo-RH-BkPln
BW: 0.0bs

Backplane Utilization
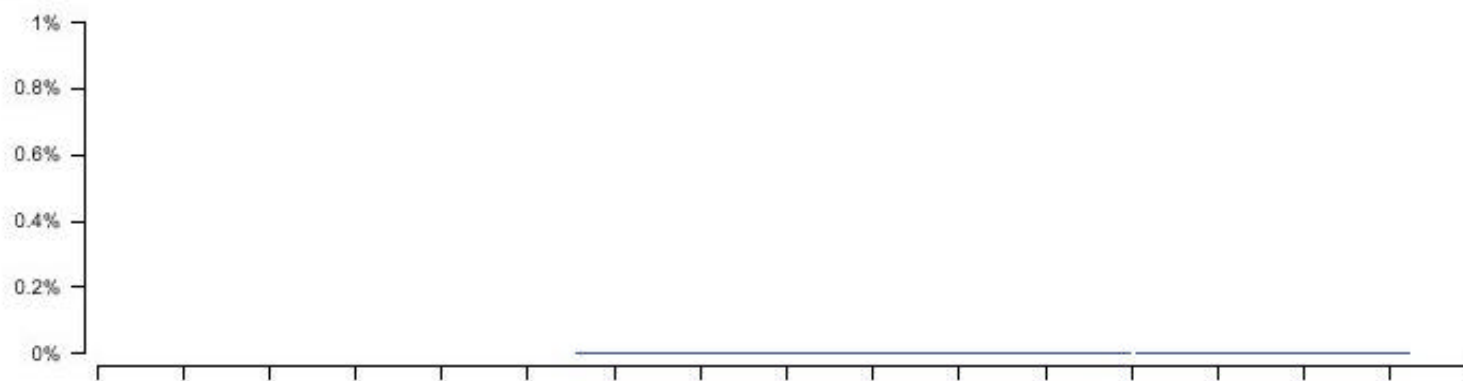
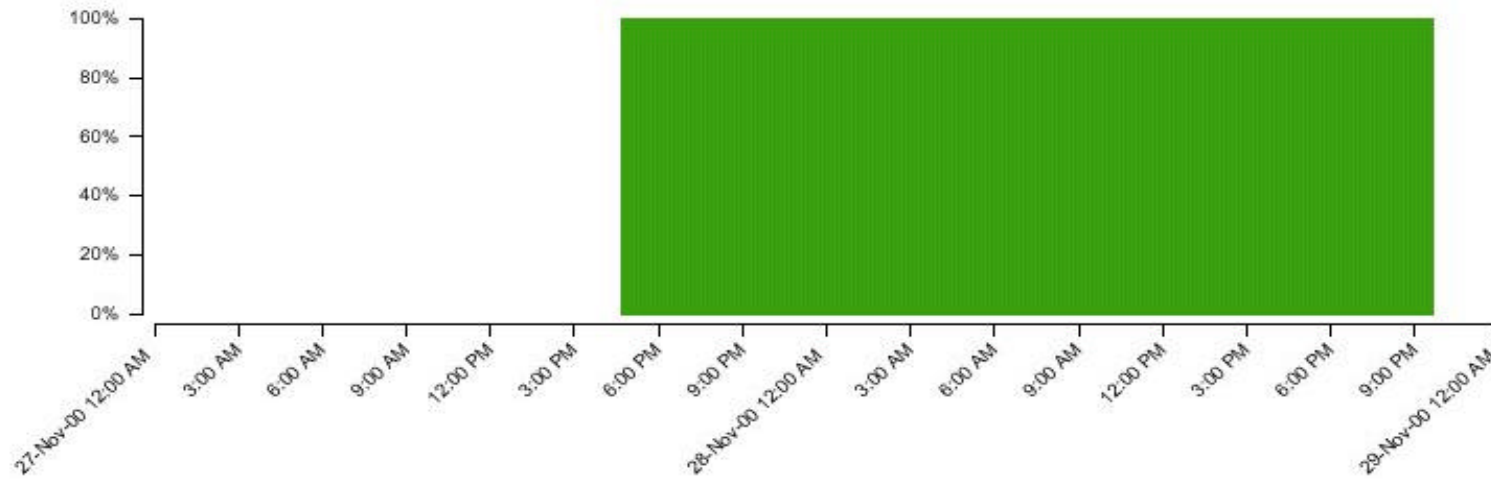Total Bytes (bytes/sec)

Latency (msec)
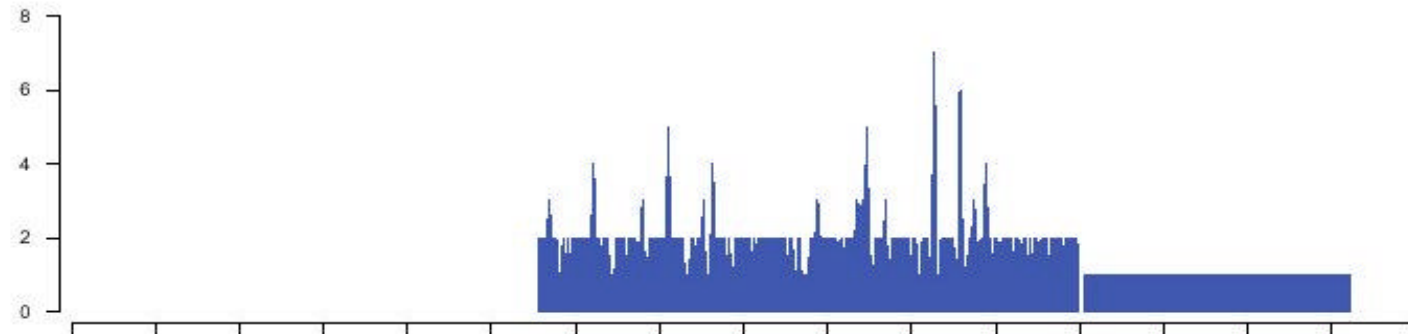
Availability

Time

Conclusions

- What, How, and Where to measure?

- Many NSF, NLANR, CAIDA, and I2 efforts have made a good start at a testing infrastructure:

  - Active and Passive Measurement
    - OCxmon
    - AMP
    - NIMI
      Surveyor

- JPL needs more and better measurement tools to support Advanced Services

- JPL needs to understand the tools

- And then what?

Framework

- (Continue to) Define a Test and Measurement Framework

- Continue to Build a Test and Measurement Infrastructure
  - Baseline
  - Interactive
  - Trending

- Which provides tools, defined variables, and instrumentation for an understandable systems view
  - All layers + Hardware

- Move forward with existing efforts

- Vendor Participation

Questions?